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Partnering as a stepping stone in the transition to PSS for the construction industry

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Abstract

The paper aims to explain and analyze how the construction industry can benefit from PSS and how collaborative approaches such as partnering can be a stepping stone in this transition. The potential sub-optimization between construction and maintenance for as well as the availability being a necessity for e.g. roads make Product Service Systems a suitable approach for improvement. Adapted solutions though the iterative design approach, co-located actors, an active buyer and functioning information flows resulted in a successful project. Interviews conducted with the buyer, the contractor and the design consultant, as well as project documentation were used to collect data.

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1. Introduction

The great amount of products and services procured every year by public authorities has leverage on the market and can influence suppliers and manufacturers to e.g. produce products and services in a more efficient way [1, 2].

Road infrastructure is often procured by a state-owned organization and through public procurement. This type of procurement is the focus of this article. For this type of infrastructure availability is critical, the lifetime spans over several decades and maintenance is needed during this time.

Business models using a life-cycle perspective where both construction and maintenance of the infrastructure is considered in the design phase could be useful for this industry. This since the use phase and thereby the maintenance phase is long, spanning over several decades. Furthermore, there is a need to construct and maintain road infrastructure in such a way that the availability is optimal. Availability refers to how much the road is open for traffic and not e.g. undergoing maintenance. This makes business models that are performance-based are relevant, since they imply that the responsible actor has the responsibility to deliver a function, and thereby also has the incentives to optimize material and energy use [3, 4]. In this way, more durable materials and other designs may prolong the lifetime of the product, and potentially optimize maintenance and operations [5].

Using the ideas from Product Service Systems, PSS, provides a possibility to add a life-cycle perspective to road infrastructure and to already in the design phase consider maintenance issues. Also, a result-based PSS, see e.g. Tukker and Tischner [6] and Mont [7], could bring a focus on quality and performance instead of lowest price bids in the rail infrastructure procurements.

Another aspect of this industry is the information asymmetry between the actors. Sharing information is important, since there often exists an information asymmetry between provider and buyer [8]. Often, the provider knows more about the product than the buyer and can therefore e.g. operate or maintain it in a better way, prolonging the lifetime or the energy consumption. In the case of road infrastructure, the contractor who realizes the solutions is likely to know more about the potential improvements than the public buyer. For

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example concerning reinforcement methods, material properties or work processes. Therefore, a shift in responsibility from specified contracts to result-based PSS, focusing on availability is interesting to investigate for road infrastructure. Furthermore, according to Fulford and Standing [9] there are great potential productivity improvements in the construction industry, and collaboration is one way to move forward. Dietrich et al. [10] confirm this by saying that extensive inter-firm collaboration is needed for the construction industry, but it is not easy to achieve. Focusing on teamwork and group efforts rather than rewards and individual effort should result in improved project efficiency, better organizational performance and stronger partnerships [9]. Due to the low perceived efficiency and the low level of formal conflict, Swedish industry could greatly benefit from partnering [11]. Partnering can be described as

"*a long-term commitment between two or more organizations for the purpose of achieving specific business objectives by maximizing the effectiveness of each participant's resources. [12 p. 4]*

The paper aims to explain and analyze how the road construction industry can benefit from PSS and how collaborative approaches such as partnering can be a stepping stone in this transition.

2. Methodology

The project studied was chosen since collaboration was an outspoken aim in the contract agreement between the actors, which is unique for Sweden. The only way to understand the complexity of the collaboration in the projects and the results from this was to interview the actors themselves. However, as a preparation documentation from the project as well as a consultant report regarding the total cost of the project compared to traditional contracting were studied. These documents served as a starting point before the interview study.

The empirical data was gathered using semi-structured interviews conducted face-to-face or over the phone, as shown in Table 1. Interviews were done with the buyer, the contractor and the design consultant to grasp the whole picture as well as to triangulate the information received.

Table 1: Interviewed respondents A-H, with party indicated.

Respondent	Role in the project	Party
A	Project leader, owner of project	Buyer
B	Deputy project leader	Buyer
C	Project leader	Contractor
D	Quality, Environment and Work environment (QEW)	Buyer
E	Construction manager, road	Contractor
F	Paving expert	Buyer, Consultant
G	Paving expert	Contractor
H	Head of design	Design Consultant

The study included both participants with managerial positions and participants that were experts in their fields, such as paving experts. This was done to get not only the top-down view, but also the perspective from a specific technology group within the project. Also, in the beginning of the study it was indicated by the respondents that a different type of technical solution for paving the road had been used, which made it natural to include the paving experts as well. However, the study focused on the management level of the project, that is how the project was run, how technical solutions were chosen, etc. Therefore, the construction workers were not included in the interviews.

3. Road infrastructure procurement in Sweden

In the construction industry, public procurement is often used and there is praxis of rewarding the lowest bid. The most common contracts within the infrastructure construction industry in Sweden are Design-Bid-Build contracts, where the procurer, the Swedish Transport Administration, specifies what to build, how to build it and how much of each element is required [13, 14]. These very specified construction contracts have shortcomings concerning weak incentives for the development of procedures [13]. A newer type of contracting, Design-Build contracts, is increasingly used and both the more detailed design phase as well as the construction phase are the responsibility of the contractor [15]. However, the overall design and performance requirements for the technical standards are set as well as followed up by the Swedish Transport Administration.

4. The studied road construction project

This article is focusing on a Design-Build project for road infrastructure outside the city of Katrineholm in Sweden. This was one of the first major road projects in Sweden using partnering, and the project was realized using less time than estimated as well as achieving a lower total cost than budgeted. The Katrineholm project had a budget of around 400 million SEK and included 20 km of highway and 11 bridges. The total cost ended up 20 million SEK below the estimation and was finished 2.5 months ahead of schedule [16].

The respondents will be addressed with their role in the project and/or the letter A-H, according to Table 1. The project was procured as a Design-Build project; this means that the contractor makes an offering on the set functional requirement decided by the buyer, in this case the Swedish Transport Administration. The contractor Skanska won the bidding process, and after this the project was remade into a traditional Design-Bid-Build project, if not the contractor would have had all the responsibility. This was a new way of working, and the concept was met with both enthusiasm and skepticism (A). The maximum number of people working during the construction was around 200.

The buyer carried the risks for the technical solutions and the contractors the risks for the execution. It was, however, a bit difficult to define exactly who was responsible for what parts since they worked together according to the contractor's Project Leader (C). Since the buyer carried 60% of the profit/loss, this actor also had responsibility for the technical solutions selected for the project. This results in a better product, since the contractor dares to suggest solutions and the buyer takes responsibility according to the buyer's Deputy Project Leader (B). Also, this meant that the buyer could turn down some solutions if necessary, and that contractor would have been more careful and conservative if the risk was split 50/50 (B). If the buyer had not been satisfied with the solutions suggested and turned them down the cooperation would suffer, since this scenario was not clearly defined in the contract (C).

4.1. Project Organization

The respondents' spontaneous description of the project was positive, and they all agreed that partnering is a good way to build good roads for less cost. The project was characterized by a nice ambience, openness and communication, and a contractor respondent as well as the design consultant went even further and concluded this to be the most fun project they had worked with in their careers. It felt like everyone involved worked for the same company, no matter the logo on the hat. They built a good quality road, much according to the respondents to the cooperation they enjoyed.

When it came to the daily operational and technical production issues the buyer's Deputy Project Leader (B) was in charge, while the Project Leader (A) focused more on the big picture and the overall financial situation. This implied communication mostly with the contractor's Project Leader (C), Construction Manager (E) and Controller when decisions regarding cost and time affected large parts of the project.

Informal communication permeated the entire project, and this was possible because the parties were co-located close to the construction site. It also meant short information paths and lead times for decisions.

During the interviews it was investigated who the respondents communicated with within the project, which kind of information they exchanged, and how often. Fig. 1 shows an overview the major information flows in the project according to the respondents.

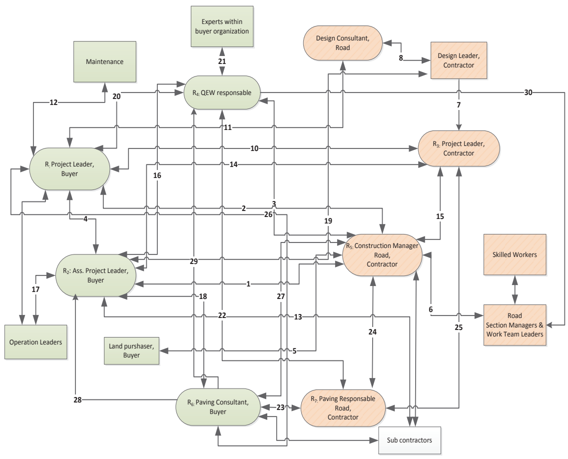

Fig. 1: Information and communication flows between the actors in the project. The striped boxes to the right in the figure are part of the contractor's organization. The oval boxes represent the respondents.

4.2. Active participation of the buyer

It was determined early on that the buyer would actively carry out tasks in the project. The buyer had e.g. a number of managerial roles, which had not happened before. In some cases, the buyer also supervised subcontractors. The QEW responsible (D) was a consultant for the buyer, but was also responsible for the contractor's parts of the project related to QEW. The buyer was also involved in the purchasing of sub-contracts as well as land acquisition, making it possible for the contractor's Project Manager (C) to sign an agreement that the buyer's purchasers had reached with subcontractors. The normal procedure is to have one representative from each side managing the process. The project used open books, which meant that the contractor's budget was available for the buyer, but only a few samplings were done (A).

4.3. Shared goals

There was an outspoken aim to develop the organization into one team and make it work (A). According to (A), the goals for the project were followed up to make sure the partnering agreement and cooperation was more than just a piece of paper.

The buyer's Project Leader (A) stated that he tried to plan so that they would be finished earlier than expected. Therefore, clear and tough financial and time goals were set. Respondents from the contractor (C & E) believed that this contract was contrary to traditional contracts, where the cheapest tender is selected and then the costs normally increase the longer the project is running. Instead, here the cost was reduced during the course of the projects and the focus was to build as cheap as possible without unnecessary emphasis on some parts, which can happen sometimes since the contractor wants to make money.

Much came down to communication and the process needed to be adjusted for this to work; e.g., elements were interrelated and therefore needed to be finished at certain times in order not to interfere with each other (A). The contractor's Construction Leader (E) stated that to sit down and jointly search for milestones and deadlines has not been done like this before. In traditional Design-Bid-Build the contractor prioritizes other things than the mutual process (E).

4.4. Design in Collaboration

Representatives from the buyer, contractor and design consultant were co-located during the design phase, and they all felt this was a good forum to openly and unconditionally discuss the benefits and drawbacks of different technologies and solutions. It was a creative process, and they could analyze the solutions to see what worked best (A). The contractor's respondents (C, E & G) felt that the whole process was smoother, easier and faster than usual. When someone came up with a design proposal the Design consultant (H) could immediately investigate it, which according to the respondents shortened the lead times in ways that are not even comparable to a traditional contract.

Brainstorming sessions were used where all ideas were written down, motivated and then formulated by design consultants and specialists. This was a process used by the actors to generate new ideas. This process generated all the cost saving ideas (C & E). The goal was to make as few errors as possible and avoid unnecessary costs during the project. According to respondents (A-H) an important part of the project, and particularly in the design, was that there was acceptance for questioning. Both buyer and contractor questioned the solutions and required justification for the decisions (F). This is not normally done in road construction projects, since the description of the solutions is viewed as a requirements document.The brainstorming phase lasted a few months, and took less time than a conventional construction phase because everything was concretized until it was almost applicable; thereafter, the so-called active design approach was used. Active design means that the design was not fully completed when construction began.

It was quite difficult to work with active design because things were determined as the construction went on, and it was difficult to reach out to everyone regarding this (B). One example of this was that they wanted the excavator operator to report ground conditions and then it was decided how the work should be done with respect to the findings. This was one of the most worked on areas regarding communication, since the participants were used to follow set directions, which created a mental threshold in this project (B). The possibility to be on-site and see what worked made this project, from the buyer's Deputy Project Leader (B) perspective, the most fun of his career. The Design Consultant (H) stated that the possibility to follow the project and actively participate the whole way was inspiring, and the project was the most enjoyable of his entire career as well.

In general, there were no major technical changes; instead, they focused on what they usually did, but tried to make it better. This was due to the actors not being accustomed to arriving at new solutions, and that they therefore had little time to make any major changes (C).

4.5. Life-cycle perspective considerations

Respondents were also specifically asked about the maintenance perspective during construction, and if there was a life-cycle perspective in the project. They were consistent in terms of lack of maintenance perspective in the project. The maintenance part is easy to forget about when their representatives are not on site (D). The maintenance representatives were invited to consultations, but they did not actively participate in the partnering part (B).

According to the contractor's Project Manager (C), the buyer's investment and maintenance divisions do not currently work together to get the lowest life-cycle cost. Also, the maintenance division has more benefit from interfering in the construction part than the other way around, and this could have been improved in the project (D). In the project it is the construction cost that is evaluated, not the life-cycle cost (F).

The buyer's Project Leader (A) states that the project was too small to include maintenance, and even if it was nothing would have been done differently. On the other hand, some solutions would have been different and this was discussed to some extent, but it was the building that was in focus and therefore they did not, according to the contractor's Construction Manager (E), take into account the life-cycle.

Another perspective, represented by the buyer's Deputy Project Leader (B), is that including maintenance is a must in Design-Build projects, since without incentives to build with quality it is tempting to build simpler and with reduced quality. However, these integrated contracts would primarily be for new investments, since reinvestments will include too much uncertainty (B). According to the Deputy Project Leader (B), uncertainties are mainly due to a lack of data for the infrastructure, which would lead to the contractor either charging a risk premium or taking shortcuts in construction.

In general, the contractor representatives would have liked a clearer focus on the environment so that it would have been possible to use more expensive, but environmentally friendly, solutions. At present, there is a lack of support for this kind of thinking from the buyer side (C). If economic incentives were connected to environmental thinking, this would drive innovation in the industry, as stated by the contractor's Project Leader (C).

4.5.1. Clay instead of plastic cloths

As described above, some technical solution had more of a life-cycle perspective and clay instead of plastic cloths is one of them.

To protect the ditches on the side of the roads and thereby nearby water from e.g. oil leakage from accidents, plastic cloths are normally used. Design consultants add them too often since it is a standard procedure (B). However, during construction it was discovered that the mud on the site could be used for the same purpose, since it had good properties to protect against contamination. Additional clay was also bought from nearby as a complement. Visual inspection of the areas was used to determine when to use plastic cloths, resulting in approximately one-third of the route lacking cloth (B). The reduction of environmental impacts from using clay instead on plastic cloths was larger than the reduction from all the efforts of reducing the environmental impact from transports in the project (B). Another benefit of the clay was that it can be dug out of trenches and replaced if it becomes contaminated. Plastic cloths can easily break from aging or digging when removing contamination, causing extensive work to restore the ditches. The buyer normally does not take these ideas into account in a project, but here the solution provided concrete proof for how environmental measures and costs are linked (C).

4.5.2. *Paving adapted for each lane*

Another technical solution with a life-cycle perspective was the paving, which was adapted to the respective lanes of the road, that is the normal lane and the fast lane, resulting in a 1 million SEK cost reduction compared to the tender (A). In general, it is estimated that 10% of the heavy traffic will use the fast lanes, but for this case the estimation was only 1% (F). One layer of paving was therefore replaced with gravel in the fast lane, reducing costs. Certain stretches were constructed according to the standard to be able to compare the outcome over time.

A life-cycle cost calculation for the paving was realized, but the client did not feel that it was reliable enough to be used for decision making (F). However, it could have been possible to optimize the material since the requirements could be based on the project, as benchmark data was not needed (F). The idea was to investigate different paving models to optimize the paving from a life-cycle cost perspective. However, it was not a priority in the project and, because it was the construction cost which was evaluated, it was hard to see the benefit of including maintenance costs in the model (F & G).

5. Discussion

In this section the research questions are discussed, starting with the partnering and collaboration as a whole. Subsequently, the information and knowledge transfer within the project is discussed, followed by a discussion of the effectiveness and resource efficiency of the project.

5.1. Successful partnering and collaboration

According to Fulford and Standing [9], there are great potential productivity improvements in the construction industry, and collaboration is one way to move forward; this was the case for the Katrineholm project. Large complex projects like this require many different competences, and according to Jelinski, Graedel *et al.* [17] they are rarely found within one company. The buyer, contractor and design consultant in the Katrineholm project had a close collaboration, and reduced the total cost and the environmental impact as well as finishing ahead of time.

The actors involved all thought the project was successful, both in terms of cost and time but also in terms of the working procedures. The project had an explicit focus on working together as a team with shared goals, which according to Fulford and Standing [9] is essential for improved project efficiency and performance. All the respondents felt that the collaboration worked very well. This is not always the case, due to the change of mindset required from public buyers which is the number one problem in partnering [18].

The buyer carried the responsibility of the technical solutions and the contractor the responsibility for the actual execution, in a way to align the efforts in the project; see e.g. Dietrich, Eskerod *et al.* [10]. However, the project did not have a clear mechanism for problem solving. According to Naoum [19] a clear functioning mechanism is an ingredient for successful partnering. Without these mechanisms, the parties might go back to traditional thinking when problems arise [20]. This never happened in the project, but the several respondents raised the question.

5.2. Increased Information and knowledge transfer

The project was characterized by trust among the actors, which implies increased collaboration and quality knowledge integration see e.g. Dietrich, Eskerod *et al.* [10]. The respondents stated that the increased level of trust improved the information sharing, and they worked together in the design and construction to find the best solutions, using their individual knowledge and experience. Dietrich, Eskerod *et al.* [10] states that the ability to turn knowledge into action, i.e. knowledge integration, leads to project success, learning and innovation.

Including the contractor in the design phase made a big difference, since this actor had the knowledge of implementing the technical solutions compared to the buyer and the design consultant. This made the knowledge base of the project larger than the sum of the individual knowledge of the actors; see e.g. Trott [21]. In this way, feedback about implementation was immediate and the solutions could be adjusted accordingly. The earlier in the process the contractor is involved, the better the opportunities are to adapt the content and the realization of the project to its specific conditions and the requirements [15]. The iterative feedback loop between construction and design through the active design approach has proven to be an efficient way of adjusting for the conditions at the sites. Additionally, a dialogue between the design and construction could provide a longer life for the infrastructure since it helps the design consultant to foresee consequences of the design and modify it accordingly; see e.g. Boothroyd and Alting [22].

It is the design phase that has the largest influence of the environmental performance in a life-cycle [23], and in this case the technical solutions were adapted to the conditions at the site, thereby improving the resource efficiency. This shows the importance of knowledge transfer between different technical disciplines when the sub-systems within the project are so interrelated. Fig 1. illustrates how the information and knowledge flowed within the project. In general, the respondents felt that including maintenance questions in a more direct way when building would make a difference in material choices and quality. By contracting for construction without maintenance, consideration can lead to sub-optimization of resources, i.e. that technologies and materials that are chosen are not optimal from a life-cycle perspective for the infrastructure [24].

It sounds logical to adapt solutions to suit the conditions at the site. The contractor, however, had gained access to information about the site in order to make an offer. Since changes were made during the project, this indicates that the client did not provide adequate information for the contractor to provide an optimal tender. It seems like some decisions are better taken on-site after carefully investigating the conditions, implying the importance of flexibility in the design. This can only happen if the buyer does not specify every technical detail but instead procures a more result-based contract based on performance, such as a PSS approach. An experience contractor could already in the design phase of a construction contract adjust so that the maintenance phase also is optimized, see e.g. Alonso-Rasgado and Thompson [25] and Toffel [26]. However, this requires that the buyer use performance requirements as incentives.

The respondents have varying opinions about what could be done differently and to what degree. In this project, it was only the construction cost that mattered and maintenance costs were not evaluated. If instead, as was suggested by the contractor, qualifications and criteria were connected to environmental measures, there is a possibility to include the life-cycle perspective as well. Considering the leverage on the market by public authorities, this indicates a development potential for infrastructure managed by pubic buyers [1, 2].

6. Conclusions

Partnering resulted in close collaboration and increased trust among the actors; this and the co-location led to exchange of information, and especially informal communication. Information was easily accessed and transferred between the actors, and the cooperation facilitated knowledge transfer between the different functions. This cut the lead times on information transfer and decision making, especially in the integrated construction and design phase, making the project more efficient.

The success of the project suggests that partnering could be a way forward in the road infrastructure industry. However, even more resource-efficient solutions could have been chosen if the project had a life-cycle perspective using e.g. a PSS approach. A result-based PSS would fit well due the result provided, the availability, is critical. Another possibility is that the buyer, the Swedish Transport Administration, who owns the road and will carry the cost for the maintenance, had a life-cycle perspective internally. In this way, requirements based on the life-cycle of the road could be incorporated into the project without the project itself having a long-term perspective.

Normally when discussing PSS it is said that the provider should take all the responsibility for the solution [3, 4, 27]. However, in the case of road infrastructure this article shows that working together in a partnering contract actually provides important benefits. This is in line with literature arguing that co-creation of value and focus on collaboration are needed in result-based models, see e.g. [28]. This is why the life-cycle perspective and the result-based focus from the PSS could be combined with increased collaboration and partnering in the road infrastructure industry to create incentives for more cost and resource efficient solutions.

The next step in this research would be to further investigate the role of a life-cycle perspective in such projects to see the impact, financially and environmentally, when applying a long-term perspective. Furthermore, it would be interesting to look more into collaboration and partnering for these types of projects.

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